# HEMCO: **H**armonized **Em**issions **Co**mponent as a versatile multi-model emissions component implemented in MUSICA/CAM-chem

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# Emissions are at the heart of atmospheric chemistry modeling
yet have several limitations in current models

**Need to preprocess inventories**

to model grid

to target chemical scheme

with ad-hoc tools

using time and disk space

**Difficult to share data and code**

**Source of human error**

in pre-processing

for different cases/variations

in reproducing past results

**Wide range of sources**

possible inconsistent treatment

double counting/undercounting

# HEMCO is a powerful on-line emissions component that can (mostly) be controlled by a text-based *configuration file*

```
# ----- REGIONAL INVENTORIES ----------------
    --> APEI               :        false
    --> NEI2011_HOURLY     :        false
    --> NEI2011_MONMEAN    :        false
    --> MIX                :        false
    --> DICE_Africa        :        false
# ----- GLOBAL INVENTORIES ----------------
    --> CEDS               :        true
```

**HEMCO Emissions Data Library**

*Gridded global and regional inventories*

**HEMCO Extensions**

*State dependent emission algorithms*

*(Biogenic, Dust, Lightning, …)*

*& GFED, Volcano, Ship Plumes…*

**CAM-Chem/MUSICA**

**CESM-GC**

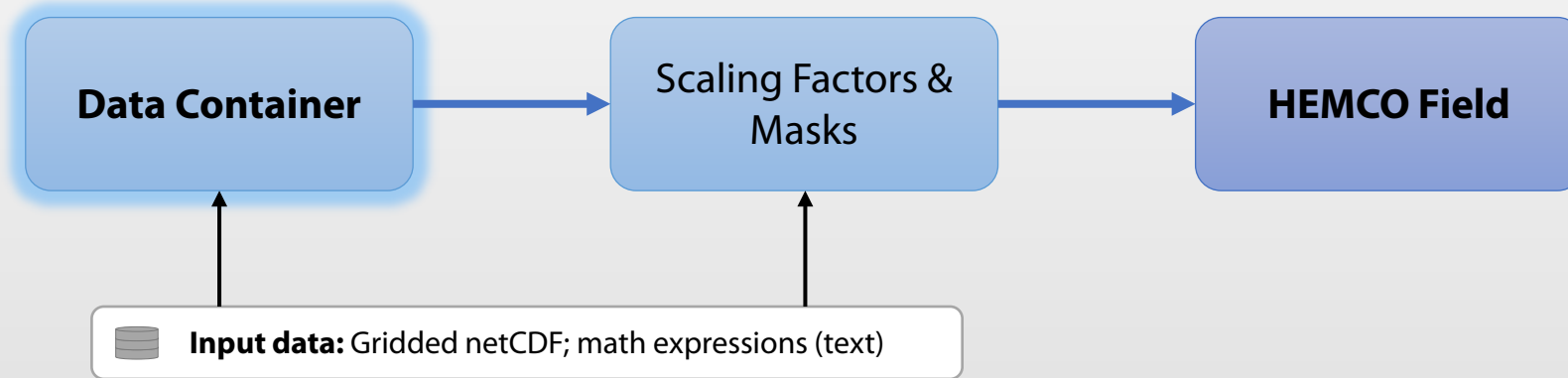GEOS-Chem 'Classic'

GCHP

WRF-GC

NASA GEOS (GEOS-GC)

**Scaling, masking, and adding emissions *from different sources, regions, and species* at runtime *on a user-specified grid* without preprocessing!**

*Keller et al., 2014; Lin et al., 2021*

# How does HEMCO accomplish this?

"**HEMCO Fields**" are the basic building block



```
0 CEDS_NO_AGR   NO-em-total-anthro_CEDS_$YYYY.nc NO_agr 1970-2017/1-12/1/0 C
    Container name    Source netCDF file                    Variable   Date range (Y/M/D/H)      Cycling Opt

xy kg/m2/s NO                      25/1234      1       5
Dim Unit          Model Species Name     Scaling Factors  Category    Hierarchy
```

**Example:** Emissions data container in HEMCO.
Tokens like $YYYY, $MM, $DD, $HH are automagically replaced into file names

**Cycling option:** *e.g.,*
- C: cycle closest
- R: only use within range
- RA: range, otherwise avg
- A: average
- I: interpolate nearest two
- E: must be exact match

# Putting it together: HEMCO configuration file demo

# HEMCO 3.0 as implemented within CESM2 – HEMCO_CESM interface

**HEMCO as a separate component in the atmosphere allows
serving of data to any atmospheric component, independent of "the outside world"**
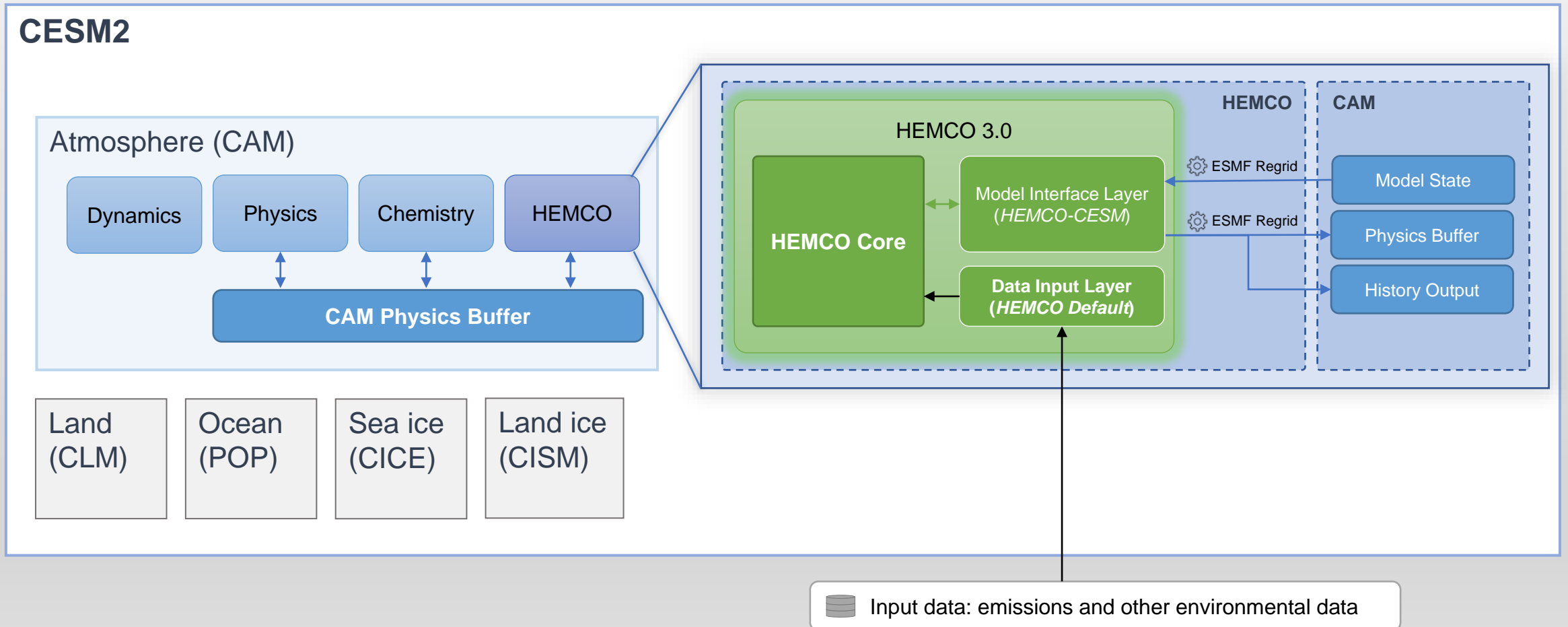
# HEMCO is fully operational in CESM2 – MUSICA/CAM-chem
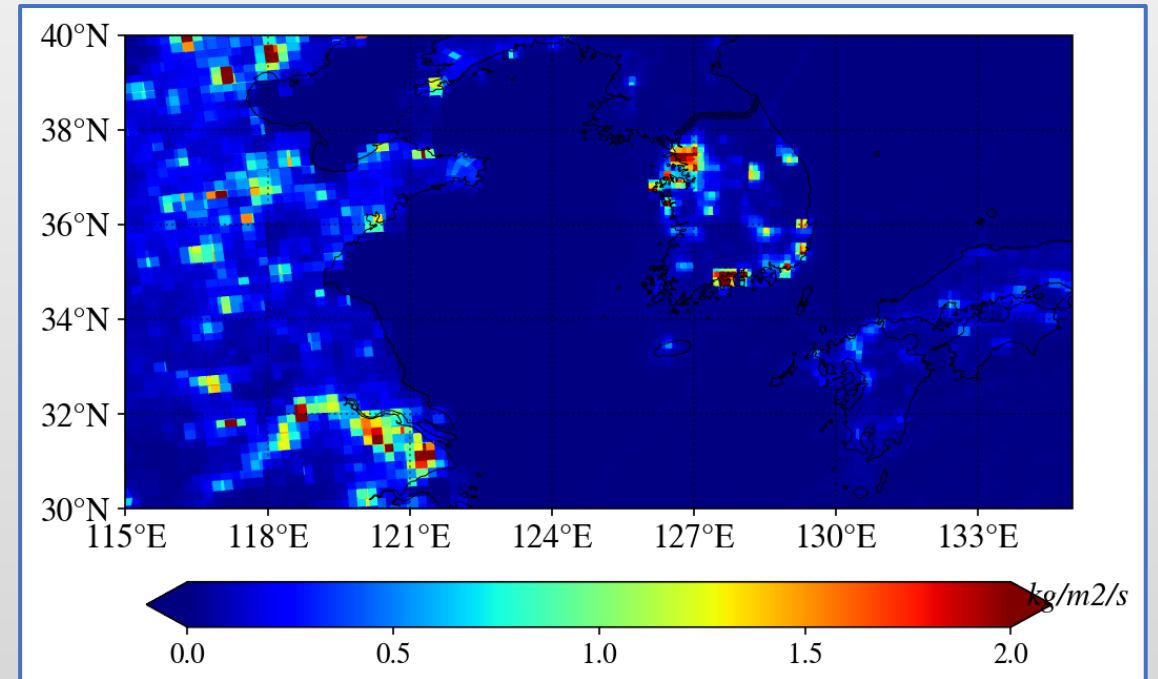
- **All HEMCO emissions are computed at runtime and available in the physics buffer.**

- Also available as output fields in the master field list.

- Grouped by species: HCO_NO, HCO_NO2, etc.

- Available over the entire vertical if emissions are 3-D (extfrc_lst) or over the surface only otherwise.

**HEMCO-CESM output** (HCO_NO)
On MUSICA Korea grid, HEMCO internal res 0.15x0.15deg



*Using Vivaldi-a package for Plot_2D*
*Credit to Duseong Jo for Korea MUSICA Grid*

# I want to give HEMCO/HEMCO-CESM a try!

- Thank you! ☺

- HEMCO on the CAM-chem wiki: https://wiki.ucar.edu/display/camchem/HEMCO

- Git repositories:
  - **HEMCO** Core code, including Extensions: https://github.com/geoschem/HEMCO/
  - **HEMCO-CESM** interface: https://github.com/ESCOMP/HEMCO_CESM
  - **Configuration files** for CAM-chem/GEOS-Chem within CESM: https://github.com/jimmielin/HEMCO_CESM_configs/

- Please feel free to reach out to me with any questions or bugs!

- Generic HEMCO questions can be asked at the HEMCO GitHub as well (supported by the GEOS-Chem Support Team)

# Other useful resources

- HEMCO User's Guide: https://hemco.readthedocs.io

- HEMCO references:
  - HEMCO 3.0 – implementation in several models, including CESM: https://gmd.copernicus.org/articles/14/5487/2021/ (Lin et al., 2021)
  - HEMCO 1.0 – original reference: https://gmd.copernicus.org/articles/7/1409/2014/ (Keller et al., 2014)

- HEMCO in MUSICA:
  - Pull request with setup instructions: https://github.com/ESCOMP/CAM/pull/560

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